Barcode Medication Administration: Lessons Learned from an Intensive Care Unit Implementation

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Abstract

An electronic barcode medication administration system was successfully implemented in the acute care and long-term care sections of a 118-bed Veterans Administration hospital beginning in February 2000. Known as Barcode Medication Administration (BCMA), the software was designed to improve medication administration accuracy and to generate online patient medication records. The application was created by the Eastern Kansas Health Care System and the Colmery-O'Neil VA Medical Center, and was modified to meet the general requirements of all U.S. Veterans Health Administration (VHA) medical centers. The nationally implemented Barcode Medication Administration software enables users to document electronically the administration of medications at the bedside, or where other points of care are involved. Barcode technology and real-time network connectivity are used to improve the accuracy of medication administration.

The barcode software implementation proved problematic in the 10-bed intensive care unit (ICU) for a number of reasons, including a lack of functionality related to the documentation of intravenous fluid administration and the need for immediate software access for urgent medication documentation. The ICU staff stopped using the BCMA software in November of 2000, eight months after the initial implementation. Department of Veterans Affairs' programmers made additional enhancements to the software and the BCMA program was re-implemented in November of 2002. Staff and management confidence in the enhanced software remained weak following the re-implementation, so a system of dual documentation for medication administration was maintained for a period of 12 months. A multidisciplinary group also was convened to facilitate the resolution of issues related to the use of BCMA for the safe administration and documentation of medications prescribed for patients following open-heart surgery. This complex patient population was selected purposely because delays in critical medication administration can produce life-threatening results. Solutions identified in the treatment of such priority patients would lead to improved care for all ICU patients.

This article explores some of the lessons learned during the BCMA implementation in the ICU. Barriers to eliminating paper record documentation will be discussed, as will the types of support needed by nurses and pharmacists in the safe transition to electronic barcode medication administration in an ICU setting. The particular ICU setting described in this study is a combined medical-

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surgical unit that provides care for approximately 200 open-heart surgery patients per year.

Introduction

Medication errors are a serious public health threat. According to a landmark 1999 Institute of Medicine report, between 44,000 and 98,000 Americans die annually due to medical mistakes.[1] As part of its ongoing efforts to improve patient safety, the U.S. Food and Drug Administration (FDA) ruled on April 4, 2004, to make barcodes mandatory on the labels of thousands of human medications and biological products by the year 2006.[2] The FDA has predicted that the ruling* will prevent nearly 500,000 adverse events and transfusion errors over the 20 years that follow, at a cost savings of $93 billion.[3] Although the ruling makes the National Drug Code (NDC)-format barcodes mandatory only on medication packaging produced by drug suppliers, there is hope that this policy will bring about technological advancements in prescription ordering, drug dispensing, and medication administration across all arms of the nation's health care system. Equally important, as the use of medication barcode technology grows, the health care institutions will need to be mindful of related changes in accreditation and compliance policies that are certain to occur within several regulatory organizations, including the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the National Committee For Quality Assurance (NCQA).

This article is intended to explore a few of the key lessons learned during the implementation of a barcode medication administration (BCMA) system in an intensive care unit (ICU) at the Harry S. Truman Memorial Veterans Hospital in Columbia, Missouri. Human factors issues, verbal communication, and the need for adequate administrative and technical support for nurses and pharmacists during such a transition will be discussed. Although it is recognized that the accuracy and clinical appropriateness of computerized physician order entry by providers has a significant potential impact on BCMA functionality and patient safety, this article focuses instead on those issues relevant to the BCMA software end-users.

Background

BCMA software is presently in use at U.S. Department of Veteran Affairs institutions operated across the nation by the Veteran's Health Administration (VHA).[4, 5] This software application, which utilizes barcode technologies in combination with real-time Ethernet local area network (LAN) connectivity with a centralized computer, was designed to improve the accuracy of the medication administration process at the hospital bedside or at other points of care. The system was first developed in 1995, at the VA Medical Center in Topeka, Kansas,

* Accessible at http://www.fda.gov/cber/rules/barcodelabel.pdf.

and was introduced nationwide in 2000. It is modified and upgraded on an ongoing basis to meet the general needs of all the VHA medical centers.[5–7]

Briefly, the VHA's medical record structure is contained within an interactive electronic client/server database system that is used to manage all clinical, infrastructural, administrative, and financial aspects of military veteran healthcare throughout the nation.[8, 9] The medication administration workflow begins when a provider makes an electronic entry detailing a patient's medication orders.[10, 11] The newly entered orders then appear in the pharmacy software package (Figure 1) to be edited and verified by a pharmacist.[12]

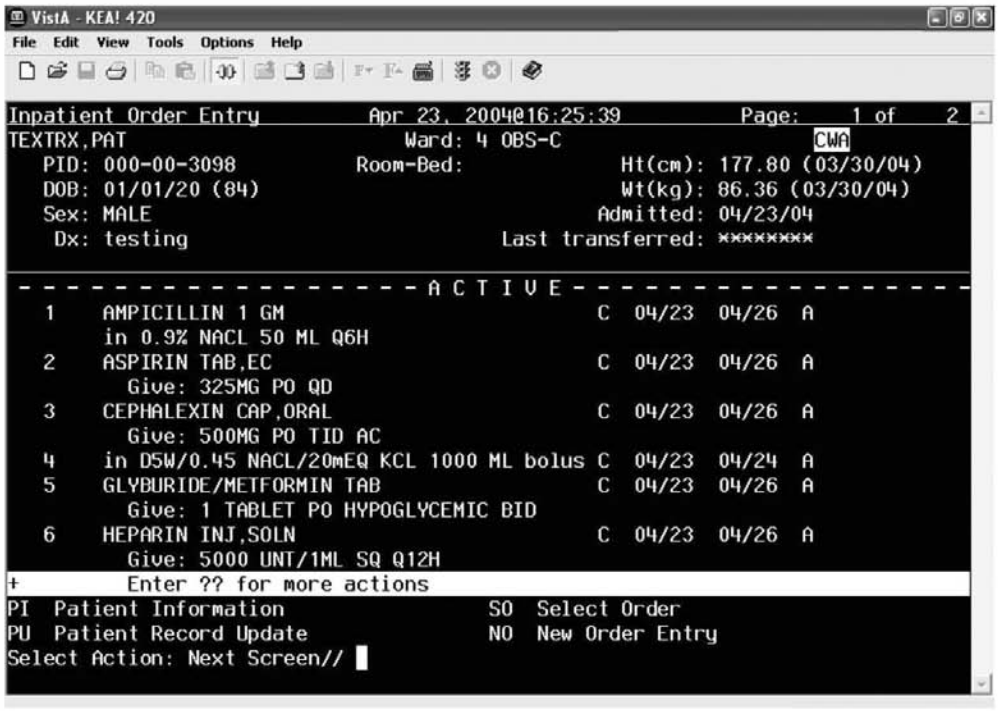
Verified orders become available in the nursing staff's point-of-care BCMA (Figure 2). The Virtual Due List (Figure 2, #2) is the electronic counterpart of a Medication Administration Record (MAR), and is used to display medications and the appropriate administration time frame for each.[7, 13] Medications may be scanned and administered, following a medication orders verification by a registered nurse.

As a handheld barcode reader registers each medication, the software verifies the correct medication was ordered, administered on time, and measured in the correct dosage, while at the same time documenting the actual administration of the medication. This process ensures the "Five Rights" universal standard of medication administration is maintained.[14] Once the medication administration procedure has been completed for a particular timeframe, the nurse uses the Missed Medication function (Figure 2, #3) to generate a report of omitted medications and takes steps to resolve any reported discrepancies.

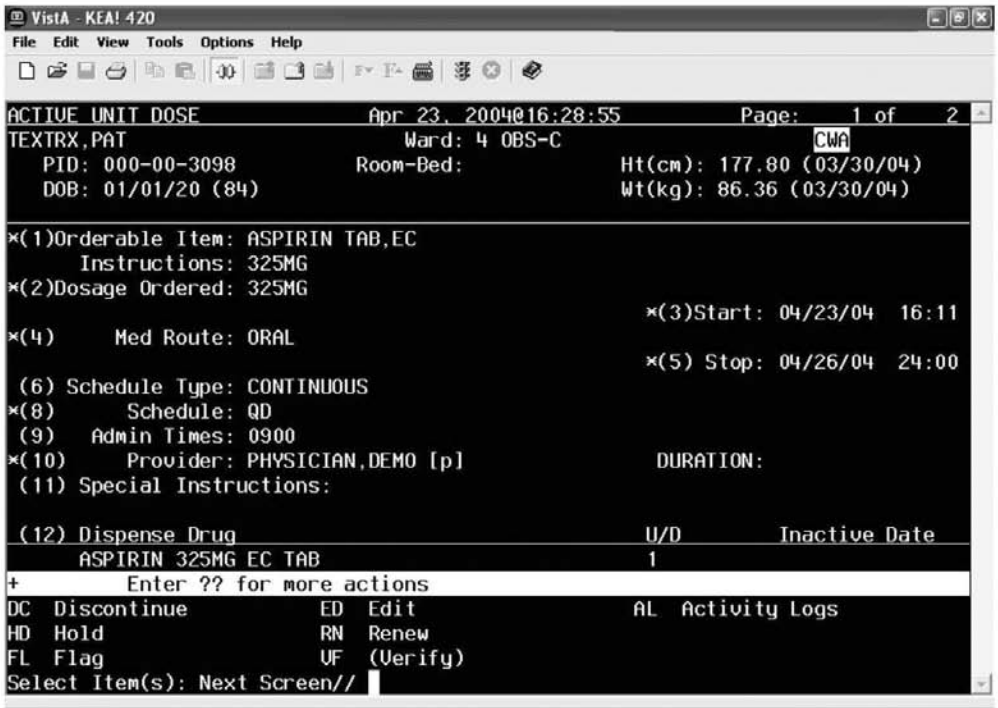
The acute care and long-term care areas at the 118-bed Harry S. Truman Memorial Veterans Hospital were the first to benefit from the BCMA system implementation. The hospital's ICU is a 10-bed combined medical–surgical unit that provides care for approximately 200 open-heart surgery patients annually. The initial BCMA software implementation in March of 2000 was problematic for several reasons, including the software's limited ability to document intravenous fluid administration and other limitations related to the timely processing and documentation of urgently needed one-time medications. Use of the BCMA software ceased in November 2000, just 8 months after its implementation. The hospital's patient safety manager and nurse BCMA coordinator performed a root-cause analysis of our institution's BCMA process, and submitted their findings to the VHA. The BCMA system was reimplemented in the ICU in November 2002, following significant restructuring and software enhancements.[5] Due to a lack of confidence in the software, however, a system of dual medication administration documentation (i.e., paper records backing up the BCMA system) was maintained during the first 12 months following the reimplementation. The ICU formally converted to an electronic medication administration environment in November of 2003.

Figure 1. Pharmacy order-verifying software program screen displays

A.

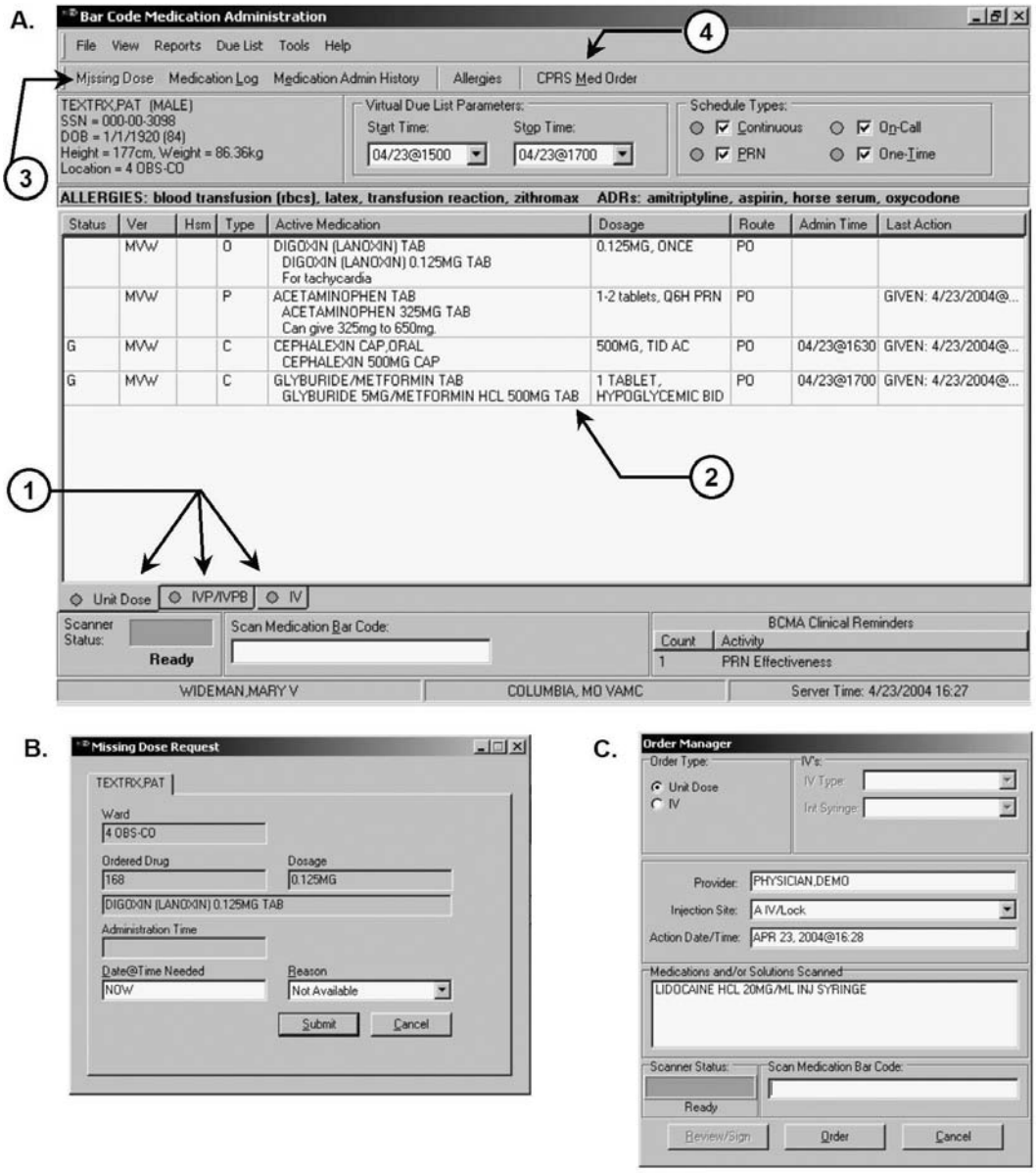


B.



Panel A: A sample patient profile displayed using the characteristic text-based terminal interface.
Panel B: Medication entry finishing profile for an individual drug entry.

Figure 2. Nursing point-of-care BCMA program screen displays



Panel A: Bar Code Medication Administration (BCMA) appears as a windows-based display. Key components include the medication administration route tabs (#1), the Virtual Due List for medications (#2), the Missing Dose function (#3), and the Nursing Medication Order function (#4).
Panel B: Missing Dose Request pop-up window.
Panel C: Nursing Medication Order Button pop-up window.

National and local VHA BCMA collaborative development

The VHA leadership recognized the need for additional emphasis with respect to business procedures, standardization, and usability issues identified by BCMA end-users. As a result, a BCMA Collaborative Breakthrough Series Project was

implemented nationwide to assist VHA staff with positive changes in the delivery of patient care. This project is sponsored by the National Aeronautics and Space Administration (NASA) Patient Safety Reporting System (PSRS), Ames Research Center, the VA National Center for Patient Safety (NCPS), and the National BCMA Joint Program Office. Our institution's BCMA Collaborative Breakthrough Team included nurses, pharmacists, management staff, and computer support personnel. The team established an overall goal of using BCMA to safely administer and document all medications within the first 24 hours following coronary artery bypass graft (CABG) surgery, since delays in medicating patients in this complex population can produce life-threatening results. Using a series of Plan-Do-Study-Act cycles (a technique originally developed and described by Langley et al.) our team has had much success in accomplishing this ambitious aim.[15]

BCMA implementation challenges

Labeling and work-arounds

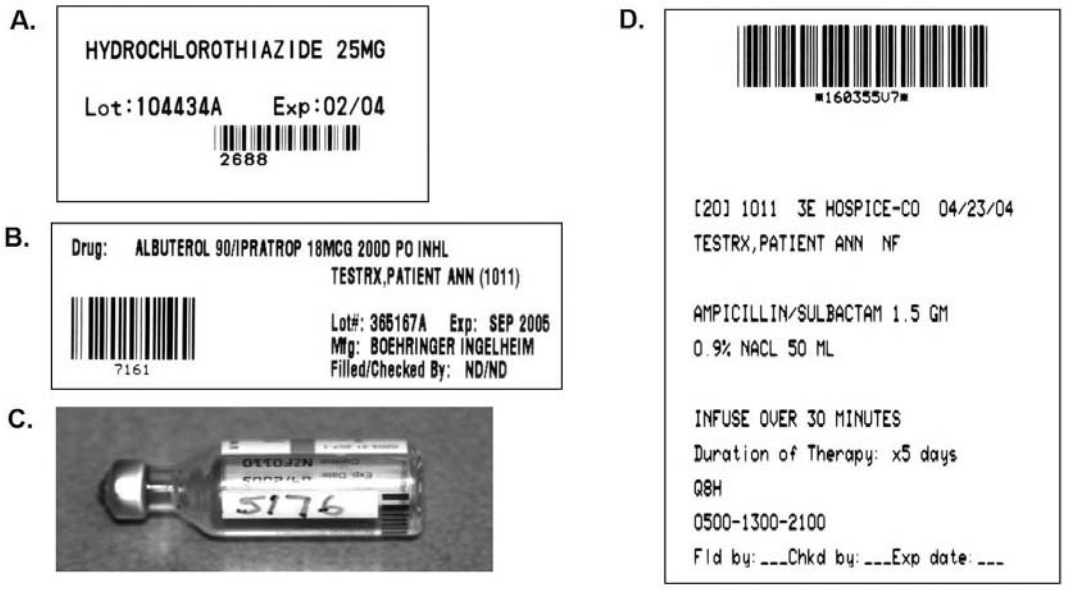
For BCMA to work correctly, the barcode from each medication must be added to a "synonym" computer file and mapped to a specific barcode in the formulary, so that recognition is achieved when the same barcode on a medication package is "read" by a handheld scanner used by the staff nurses. If a drug manufacturer's barcode label can't be scanned successfully, or if bulk-packaged products are transferred to unit dose packaging by the pharmacy staff, these items then must receive a pharmacy-generated barcode label that is affixed to or printed directly onto the outer wrap of the dose packaging (Figure 3, Panel A).

Moreover, patient-specific multi-dose medications (e.g., inhalers, creams) are affixed with special barcode labels containing the name of the patient and the prescribed drug (Figure 3, Panel B). If a medication can't be scanned on a clinical care ward, it is likely the nurse will employ a work-around technique and enter the Internal Entry Number (IEN) for the medication manually, thereby bypassing BCMA and placing the patient at significant potential risk for a medication error. An example of a work-around is shown in Figure 3, Panel C. It is the responsibility of the pharmacist to be responsive to such problems and to investigate scan failures and the return of properly labeled items in a reasonable amount of time.

Missing dose request and medication order functions

One of the most beneficial features of the BCMA software is the Missing Dose Request notification.[13, 16] Briefly, a nurse initiates the Missing Dose Request pop-up window and, via automated printouts, the BCMA system alerts the pharmacy to drug doses missing from the medication cart. The pharmacist evaluates each request, dispenses the appropriate drug, and routes the dose to the appropriate unit or ward in a timely manner, usually within the same medication

Figure 3. Examples of valid and invalid BCMA barcode samples



Panel A: Typical pharmacy-generated unit dose barcoded label.
Panel B: Example of a patient-specific multi-dose medication barcoded label.
Panel C: This multi-dose insulin vial was found during BCMA rounds. Pharmacy did not supply a barcoded label with the medication, so a member of the nursing staff wrote the IEN (Internal Entry Number) on the bottle, allowing nurses to manually type in the mapped identification number instead of scanning a barcode, thereby effectively bypassing the BCMA nursing verification algorithm.
Panel D: Example of a pharmacy-generated intravenous piggyback (IVPB) label.

administration cycle (or medication "pass"). This process has led to significant reductions in the number of phone calls from nurses to the pharmacy, thereby increasing overall efficiency. Conversely, the initial BCMA software version was not configured to accommodate urgent or one-time (i.e., "stat" or "now") medications. As much as 30 minutes could elapse between the provider's order entry and the appearance of either type of medication in the BCMA nursing interface. Subsequent versions of the BCMA software have included a Nursing Medication Order Button, which the nurse can use in response to a valid verbal or phone stat/now order from the provider to immediately order, scan, and document the delivered medication in the electronic medical record. Without this convenient feature, the BCMA system would not have been deemed acceptable for use in an acute care setting such as the ICU.

Development of the IV medication scanning function

Although the initial version of the BCMA software was considered very useful for administering unit dose medications and reporting doses missing from the medication cart, the application's intravenous (IV) medication functionality was limited.[16] In the BCMA package, nurses could mark only the IV medication field as "given." Subsequent BCMA software versions have incorporated IV label barcode scanning to better match the right patient to the right IV bag, and electronic monitoring of the IV medications chronology for repetitive

administrations such as regularly scheduled IV antibiotics.[4] ICU nurse clinicians have since identified significant additional barriers to the accurate and efficient administration of IV admixture medications and their documentation. These documentation issues are especially challenging with respect to critically ill CABG patients, who have a propensity for multiple titratable IV fluids administered simultaneously and whose IV administration rates and status change frequently. In fact, the ICU nurses at Truman Memorial Veterans Hospital still use paper ICU flow sheets to document patient response to IV medications. ICU end-users have expressed their collective desire to have automated infusion pump programming and verification incorporated into the BCMA system, and some of these features are being designed and developed by manufacturers.[17, 18]

Standardization of medication schedule types

When the collaborative team first sought to remove the paper MAR system from the ICU, the impact of various differences in the way the pharmacists completed orders for intravenous medications quickly became apparent. These differing styles were most likely due to inconsistencies in IV dosage form terminology taught at health care institutions and pharmacy schools throughout the United States. The BCMA collaborative team therefore held joint departmental meetings whereby nursing and pharmacy staff members established grass roots definitions for each respective parenteral medication category.[13] In brief, a medication infused rapidly via the intravenous method in unit dose manner was classified as IV push, or "IVP," while a medication infused intravenously as a bolus or administered over a short time period was referred to as IV piggyback, or "IVPB." The remaining IV medications fell under the IV Continuous, or "IV" route, classification.

Using triage questions developed by VHA's National Center for Patient Safety, the collaborative team decided in October of 2003 that the next crucial step in the IV schedule standardization process was the development of a straightforward color-coded cognitive tool for pharmacists that could be referenced quickly during order editing for CABG patients.[19] A condensed example of the layout of this tool is presented in Figure 4. This tool has been implemented and judged acceptable by the Truman Memorial pharmacy staff. In fact, the hospital patient safety manager in February 2004 noted the tool had been used several times in the span of 20 minutes, for cardiothoracic and acute non-ICU patient medications, following observation of an inpatient pharmacist. Since the VHA is actively improving upon the current pharmacy software package, the process should become much more intuitive to the needs of the hospital pharmacist in the future, to the possible extent that upon finishing an order, a pop-up box would suggest the proper documentation tab for a particular drug or drug combination, thereby eliminating the need for a supplemental information table.

Figure 4. Cognitive training tool developed for pharmacists

Generic	TRADE	SPECIAL ADMINISTRATION INSTRUCTIONS	BCMA ROUTE TAB
IV ADMIXTURES			
Amiodarone (maintenance)	Cordarone	900mg/500cc in glass. Special tubing provided.	CONT IV INFUSION
IV PUSH			
Acetazolamide	Diamox	Not to be given faster than 100mg/min.	IVP
IV PIGGYBACKS			
Aminocaproic Acid	Amicar	1-3gm/100cc or 4-5gm/250cc. Not to exceed 4gms in 1 hr.	IVPB

The BCMA Collaborative Team discovered that there were no pre-existing expectations for nurses as to where to find a particular intravenous medication in the BCMA program. Thus, a color-coded cognitive tool was developed to standardize IV medication order processing by pharmacists. The tool has been truncated here so as to provide one example from each of the IV medication schedule types. All intravenously administered drugs customarily used during a typical CABG patient's hospital stay were listed in table form and divided into alphabetized and color-coded IVP, IVPB, and IV CONT (continuous IV) categories. Inpatient pharmacists were then instructed on proper entry of IV medications based on the printed table.

Other BCMA software and hardware issues and contingencies

Pharmacy and nursing staff members must collaborate closely with information management staff, if the medication administration arm of a hospital care system is to work optimally, just as rapid computer response time is crucial to the success of a computerized medication administration system. The entire VHA computer network was restructured late in 2003, and all point-of-care PCs at Truman Memorial Veterans Hospital received major upgrades. As a result, computer response time and reliability were improved greatly, thereby helping to ease the eroding staff confidence in the network system. Further improvement included making the computer support staff more available and on-call around the clock to resolve hardware and software issues as they arose.

Perhaps the most crucial network system modification centered on the hospital staff's development of a BCMA Contingency Plan. Briefly, the medication administration history for each floor was periodically written to an electronic file sent to six personal computers throughout the hospital. Each of the designated PCs was provided with the capability to print each floor's medication administration history in case a technical difficulty on a particular floor prevented the report from being generated. Staff members were briefed on how long to wait before activating the contingency plan, and tabletop drills were done for demonstration purposes.

In addition to the consideration given to software issues, the success of the BCMA implementation required functional and adequate point-of-care equipment, as supported by Patterson et al.[20] During the BCMA Version 1 trial, each ICU bed was equipped with its own PC and corded (tethered) scanner. The scanner cords were long, but in some cases they would not reach the patient's wristband for scanning. This shortcoming encouraged the caregiver to bypass the BCMA system. Cordless scanners were purchased prior to the BCMA re-implementation in 2002, and nurses now can access the wristband barcodes without needing to move equipment. Additionally, a wireless laptop on a roll-around stand was deployed on the ICU unit to increase nursing staff access to the BCMA system during those instances when the bedside computer was being used by another provider.

Human factors issues

Dual versus single medication administration records

Dual medication systems (i.e., the use of paper MARs in tandem with electronic BCMA documentation) increase the probability of medication error and reduce nursing productivity, as indicated previously in a study by Patterson et al., that examined the human factors issues related to BCMA implementation in a VHA institution.[20, 21] Baseline data collected by our BCMA Collaborative Team in September 2003 indicated that 60 percent of one-time medications and 42 percent of PRN medications for CABG patients were documented in the BCMA system, so the risk of medication error was great. The ICU eliminated paper MARs on November 18, 2003, in favor of the paperless system. Since that time, the documented percentage of these same medications in the BCMA system has risen to more than 95 percent, and several nurses have expressed the opinion that their overall workload has decreased as well.

Computerized and verbal communication work hand in hand

The collaborative learned that safe, successful barcode medication administration is not a passive or mutually exclusive process, and that pharmacy–nursing staff communication is key to BCMA success. One of the collaborative team's initial core objectives involved inter-staff communications. It was seemingly straightforward and helped to answer the question asked of any pharmacist: "If you knew that a critical patient had just arrived in ICU, would this help you do your job better?" The ICU nursing staff was asked to simply call the inpatient pharmacy and notify a staff pharmacist of each CABG patient's expected arrival time in the ICU following surgery. This was done for all open-heart CABG surgeries. Nursing staff members documented the calls on the ICU flow sheet, and pharmacy staff members were directed to keep a written log of the calls. The collaborative discovered that a simple policy change requiring an

uncomplicated phone call to the pharmacy helped to ensure the timely administration of medications.

We learned a similar communication lesson during the BCMA reimplementation while attempting to solve a problem related to the handling of pre- and post-surgical IV medication barcodes for CABG patients. At a multidisciplinary meeting with pharmacy, nursing, and anesthesia clinical staff, it was discovered that anesthesia staff did not realize the importance of the barcode labels that the pharmacy had affixed to the outer wraps of IV bags. Following the meeting, the percentage of CABG patients admitted to the ICU from surgery with properly barcoded IV bag labels increased dramatically.

Personnel training

Principal staff representatives, including an inpatient pharmacist, an ICU nurse, a ward nurse, and a nursing instructor, attended a national BCMA training workshop in 2002. Upon their successful completion of the course, these individuals were designated BCMA "Super Users" and were made accessible to staff on every shift, around the clock, for assistance and training. Job-specific BCMA orientation training began in a computer lab environment, complete with PCs and barcode scanners configured identically to those on the patient care units. After an affirming competency assessment from the Super Users, the newly trained nurses and pharmacists continued their training on the job.

All nursing and pharmacy personnel now are provided with ongoing refresher training to keep staff up to date with program revisions and new technology. We also rely on multidisciplinary cross-training techniques to increase the staff members' BCMA understanding and competency. Prior to the BCMA reimplementation, all staff attended a 3-hour joint classroom session in which the pharmacists cross-trained on the nursing aspects of BCMA and the nurses cross-trained on the pharmacy-specific features. In addition, a job-shadowing initiative also has been implemented recently. User issues encountered by both parties become highly visible as pharmacists accompany nurses on BCMA medication administration rounds and as nurses observe pharmacists finishing medication orders and troubleshoot BCMA problems in the inpatient pharmacy. These crossover learning encounters have garnered very positive staff feedback since being put into effect.

Hospital clinicians have varied technological backgrounds, ranging from those with excellent computer skills to those with far lower computer literacy levels. According to Buerhaus and Staiger, the average age for registered nurses in 2000—the year of the BCMA system implementation—was 42 years old.[22] Many nurses of this age have had only limited exposure to computers. To help reconcile this issue, computer specialists at our institution developed a BCMA user's guide with numerous and detailed BCMA software screenshots to help instill confidence in users with little prior computer experience.

Cultural and management issues

Elimination of a punitive medication error reporting policy

The Institute of Medicine has recommended that health care organizations implement a "deidentified, fair, and just reporting system for errors and near misses."[23] A medication error policy with punishment potential may have been one of the most significant barriers to the success of the initial BCMA implementation. Clinical nursing staff members were assigned points based on the nature and severity of documented individual errors, and disciplinary action was to have been based on the number of points accumulated for a particular period. The nursing staff quickly recognized the computerized medication system for its potential as an error-tracking device that management could use to punish those involved with medication mishaps. This perception became highly controversial and began to undermine the efforts to implement the BCMA system.

Following root-cause analysis of the barriers to the BCMA software implementation, the medication error policy was rescinded in November 2000. The BCMA implementation group also was restructured to include key nursing, pharmacy, and computer support staff members. This new group helped to rewrite the hospital's BCMA and error policy such that punishment for medication errors was an option only when the error was associated with a criminal or purposefully unsafe act, alcohol or substance abuse by an employee, or alleged or suspected patient abuse of any kind.

Proactive management: patient safety and BCMA rounds

The development of a working environment in which communication flows freely—as in the aviation industry where the "two-challenge rule" is practiced—is essential to the growth of an institutional safety culture.[24] The Institute of Medicine has agreed: "Designing systems for safety requires specific, clear, and consistent efforts to develop a work culture that encourages reporting of errors and hazardous conditions, as well as communication among staff about safety concerns."[25] In an effort to further enhance patient safety, build front-line staff confidence, and illustrate the responsiveness and support of management to the BCMA end-users, the collaborative team and management established Patient Safety Rounds, which is modeled after the Beth Israel Deaconess Medical Center's Voluntary Reporting System.[1, 26] These informal, confidential, and voluntary rounds are conducted twice each month by the ICU medical director and the patient safety manager to gather adverse event data and information related to near misses. All occurrences reported during Patient Safety Rounds are reviewed by the hospital staff, and actual incidents or close calls are entered into the Patient Safety Information System (PSIS), which is operated by the VHA National Center for Patient Safety (NCPS).

The Patient Safety Rounds initiative has been expanded recently to include BCMA Rounds. Selected BCMA committee members observe actual medication administration cycles in the ICU in an effort to identify workflow and system

issues specific to BCMA system use in an ICU environment. Committee members also solicit feedback on any BCMA-related user issues. The issues identified during rounds and observational sessions are taken back to the entire BCMA Committee and are developed as agenda items for the Committee meetings. An unexpected opportunity for nursing BCMA system re-training presented itself during the early BCMA rounding sessions. The BCMA coordinator, who also is a nursing instructor, now assists nurses during the observation periods and works hand-in-hand with them to troubleshoot and provide on-the-job BCMA functionality training. It is not uncommon for those nursing staff who use the BCMA system to make suggestions for improving the software's functionality. To that end, staff members have been pleased to witness the implementation of improvements that they themselves requested.

In summary, while the benefits of Barcode Medication Administration are many, human factors, along with basic system functionality and architecture, need to be given careful consideration at health care institutions across the nation as they begin to address the issues associated with BCMA system development for the inpatient care setting. At the same time, nursing and pharmacy staff cooperation and support is essential during the final stages of the medication order verification process to ensure the accurate and safe administration of medications. It is also necessary for organizational leadership to promote and endorse a culture of support during the system implementation and troubleshooting period. We feel that collaborative discussion of these issues will most certainly benefit other institutions studying BCMA implementation for inpatient care settings, and will provide for a safe and well-accepted transition to electronic barcode medication administration.

As we learn more about the BCMA procedure and how it supports functionality and safety at our institution, we continue to use the skills and lessons learned from our participation in the BCMA Collaborative Breakthrough Series. Future plans include the development of teams to continue the Plan-Do-Study-Act cycles for identifying other implementation aspects in need of improvement. Finally, in addition to advancing our own successes, our hope is that by disseminating the lessons learned from our own experiences, our work may assist others experiencing similar issues related to recent FDA efforts to encourage barcode technology development in the healthcare sector.

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